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LISTS OF SPECIES

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Checklist of copepods (Crustacea: Calanoida, Cyclopoida, Harpacticoida) from Wyoming, USA, with new state records

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Abstract: I present a comprehensive checklist of the copepod fauna of Wyoming, USA with 41 species of copepods; based on museum specimens, literature reviews, and active surveillance. Of these species 19 were previously unknown from the state. This checklist includes species in the families Centropagidae, Cyclopidae, Diaptomidae, Ergasilidae, Laophontidae, Lernaeopodidae, and Lernaeidae.

Keywords: Wyoming, copepod, Centropagidae, Cyclopidae, Diaptomidae, Ergasilidae, Laophontidae, Lernaeopodidae, Lernaeidae

INTRODUCTION

Copepods are ubiquitous aquatic crustaceans. They play important roles in aquatic ecosystems ranging from herbivores and detritivores to predators of small invertebrates and parasites. Copepods are also significant food sources for many fish and other aquatic life. While often overlooked they can play a significant role in the control of mosquitoes and other invertebrates. Some of the larger copepods are predatory and feed on insect larvae and eggs. In addition, copepods are hosts to insect pathogenic microsporidia and fungi and parasitic worms of vertebrates. Copepods are essential in naturally maintaining some of these pathogens. For example, calanoid copepods are intermediate hosts of *Diphyllobothrium latum*, the broad fish tapeworm, which can parasitize humans and fish eating mammals (Janicki and Rosen 1917). Several parasitic copepods infect aquatic vertebrates and kill or injure their hosts. As a result, parasitic copepods can be major parasites in aquiculture.

Wyoming is one of the least populated states in the USA. Previous biological surveys of Wyoming describe the general geography as primarily an arid high plateau with isolated mountain ranges (Reynolds et al. 2009). It is divided into three basic regions the Great Plains, Rocky Mountains, and Intermontane Basins. The major rivers east of the Continental Divide are the Platte, Wind, Big Horn, and Yellowstone Rivers the western drainages feed into the Columbia or Colorado River Basins (Reynolds et al. 2009). To my knowledge, the copepod fauna of Wyoming has never been published in a cohesive checklist. I review published literature and extensive new collection records to produce a checklist of the copepod fauna of Wyoming including several isolated high alpine and cave habitats.

MATERIALS AND METHODS

Copepods were opportunistically collected state wide during environmental sampling of water sources for macroinvertebrates or during water sampling. Collection techniques included using a plankton sein in open freshwater habitats and killing and fixing the contents with 70% isopropanol. In addition, wet mosses, macrophytes, and submerged leaves were collected and directly examined using a dissecting microscope for the presence of copepods. These were killed and fixed in 90% ethanol. Water from the subterranean stream and drip pools in Cave Creek Cave were filtered through a plankton net in the cave and preserved with 70% isopropanol as described in past surveys (Reeves and Reid 2002). In addition, a literature review was conducted to capture and document records of copepods previously reported in Wyoming. Voucher specimens of all newly collected material were deposited in the Virginia Museum of Natural History in Martinsburg, Virginia.

RESULTS

I report on 41 species of copepods from the state of Wyoming. Of these recorded species, 19 were previously not recorded form Wyoming. This checklist is undoubtedly incomplete but has nearly doubled the number of reported copepod species from the state.

List of Species

Order Calanoida
Family Centropagidae

Osphranticum labronectum Forbes, 1882

Additional records: Both Schacht (1898) and Marsh (1933) reported this species from "Wyoming" but I did not collect representatives.

Family Diaptomidae

Aglaodiaptomus lintoni (S. A. Forbes, 1893)

Examined material: Campbell County, Coal bed methane lake No. 35, 26 August 2008, coll. W.E. Yarnell (1♀); Carbon County, small pond near Medicine Bow, 21 September 2008, coll. W.K. Reeves (1♀).

Additional records: Park and Teton Counties, Lakes and pools in Yellowstone National Park (Forbes 1893, original description, as *Diaptomus lintoni* n. sp.; Schacht 1897, as *D. lintoni*); Park County, Cliff, Fort, and Little Bear Lakes, Moose Bog, and ponds in Beartooth High Lakes Area (Williams 1976, as *Diaptomus lintoni*); Beauty Lake, Beartooth Absaroka Wilderness (Kessler *et al.* 2008).

Aglaodiaptomus clavipes (Schacht, 1897)

Additional records: Sweetwater County, Flaming Gorge Reservoir (Schneidervin and Hubert 1988, as *Diaptomus clavipes*).

Aglaodiaptomus leptopus (S. A. Forbes, 1882)

Additional records: Park County, Sill Lake in Beartooth High Lakes Area (Williams 1976, as *Diaptomus leptopus*).

Arctodiaptomus arapahoensis (Dodds, 1915)

Additional records: Park County, Beauty, Becker, Mutt, and Frozen Lakes, and a pond in Beartooth High Lakes Area (Williams 1976, as *Diaptomus arapahoensis*.); Park County, Emerald and Fossil Lakes, Beartooth Absaroka Wilderness (Kessler *et al.* 2008).

Hesperodiaptomus shoshone (S. A. Forbes, 1893)

Additional records: Park County, Shoshone Lake (type locality, Lewis, Swan, and Yellowstone lakes, and pools, including an alkaline pond, in Yellowstone National Park (Forbes 1893, original description, as *Diaptomus shoshone*; Schacht 1897, as *D. shoshone*; Marsh 1929, as *D. shoshone*; M. S. Wilson 1953); Park county Daphnia, High, Promise, Rainbow, Snyder, Windy, and Z Lakes, and ponds in Beartooth High Lakes Area (Williams 1976, 1980, as *Diaptomus shoshone*); Park County, Yellowstone Lake, Yellowstone National Park (Benson 1961, as *Diaptomus shoshone*; Tronstad 2008).

Leptodiaptomus ashlandi (Marsh, 1893)

Additional records: Park County, Alkaline pond, Yellowstone National Park (Schacht 1897, as *Diaptomus ashlandi*.); Park County, Yellowstone Lake, Yellowstone National Park (Marsh 1929, as *D. ashlandi*; Tronstad 2008); Park County, Beartooth, Island, and Wall Lakes in Beartooth High Lakes Area (Williams 1976, as *D. ashlandi*); Park County, Beartooth Lake, Beartooth Absaroka Wilderness (Cooke *et al.* 2006; Persaud *et al.* 2007; Kessler *et al.* 2008); Sweetwater County, Flaming Gorge Reservoir (Schneidervin and Hubert 1988, as *D. ashlandi*).

Leptodiaptomus minutus (Lilljeborg, 1889)

Additional records: Park County, Yellowstone National Park (Schacht 1897, as *Diaptomus minutus*); Park County, Yellowstone Lake, Yellowstone National Park (Benson 1961).

Leptodiaptomus sicilis (S. A. Forbes, 1882)

Examined material: Carbon County, small pond near Medicine Bow, 21 September 2008, coll. W.K. Reeves (5♀ 10♂).

Additional records: Albany County, West Carroll Lake, (J. A. Wilson 1966, as *Diaptomus sicilis*); Park County, Yellowstone Park (Forbes 1882; Schacht 1897; Marsh 1929).

Leptodiaptomus siciloides (Lilljeborg, 1889)

Examined material: Campbell County, Coal bed methane lake No. 19, 26 August 2008, coll. W.E. Yarnell (1♀ 3♂).

Additional records: Campbell County, Thunder Basin, and prairie pond (Suárez-Morales *et al.* 2000 - from USNM material).

Leptodiaptomus tyrrelli (Poppe, 1888)

Examined Material: Carbon County, small pond near Medicine Bow, 21 September 2008, coll. W.K. Reeves (2♀).

Additional records: Park County, Yellowstone Park (Marsh 1915, 1929; as *Diaptomus tyrelli*); Park County, Fantan, Frozen, Hauser, Little Bear, Long, Lower Chain, Lower Sheepherder, Snyder, Solar, and Upper Chain Lakes, and ponds in Beartooth High Lakes Area (Williams 1976, as *D. tyrrelli*); Park County, Kersey Lake, Beartooth Absaroka Wilderness (Kessler *et al.* 2008, as *L. tyrelli*).

Order Cyclopoida
Family Cyclopidae

Acanthocyclops einslei Mirabdullayev & Defaye, 2004

Examined material: Albany County, Optimist Park, pond, 19 June 2008, coll. W.K. Reeves (4♀); Albany County, warm spring in Laramie, greenbelt, 3 January 2009, coll. W.K. Reeves (6♀ 1♂); Albany County, Laramie, roadside ditch, 14 July 2008, coll. W.K. Reeves (4♂, 6 immature); Laramie County, North Crow Reservoir, 5 July 2008, coll. W.K. Reeves (2♀); Natrona County, North Platte River, Fremont Canyon, plankton net, 25 November 2008, colls. W.K. Reeves and R.M. Spence (1♀ 2♂ 2 immature); Platte County, Big Laramie River below

Bluegrass River diversion, 10 August 2008, coll. W.K. Reeves (1♂ 2 immature).

Acanthocyclops robustus (G. O. Sars, 1863)

Examined material: Albany County, saline pond on Hwy 230, low salinity, 7 July 2008, coll. W.K. Reeves (4♀ 2♂ 46 immature); Carbon County, Arlington, pool of water, 14 June 2008, coll. W.K. Reeves (2♀ 2♂ 2 immature).

Additional records: Park County, Beauty Lake, Beartooth Absaroka Wilderness (Kessler et al. 2008).

Acanthocyclops trajani Mirabdullayev & Defaye, 2004

Examined material: Albany County, "Stink Pond" sulfur pond and spring, 11 November 2008, coll. W.K. Reeves (1♂, 4 immature); Campbell County, Coal bed methane lake No. 19, 26 August 2008, coll. W.E. Yarnell (4♀ 2 immature); Campbell County, Coal bed methane lake No. 23, 26 August 2008, coll. W.E. Yarnell (6♀ 2♂ 4 immatures); Campbell County, Coal bed methane lake No. 24, 26 August 2008, coll. W.E. Yarnell (3♀ 2♂ 3 immature); Campbell County, Coal bed methane lake No. 32, 26 August 2008, coll. W.E. Yarnell (6♀ 2♂ 4 immature); Carbon County; Cave Creek Cave, 23 September 2008, coll. W.K. Reeves (3♀ 4♂); Carbon County, Shirley Mountains, Middle Cave Creek, 3 November 2008, coll. W.K. Reeves (1♂ 1 immature).

Acanthocyclops vernalis (Fischer, 1863)

Examined material: Albany County, Libby Flats, pools of water, 12 June 2008, coll. W.K. Reeves (1♀); Albany County, warm spring in Laramie, greenbelt, 3 January 2009, coll. W.K. Reeves (1♀); Carbon County, Encampment, cattle pond outflow, 28 June 2008, coll. W.K. Reeves (5 immature); Crook County, spring along road near Hulett, Black Hills, 19 June 2008, coll. W.K. Reeves (2♀ 3 immature).

Additional records: Park County, Emerald Lake, Beartooth Mountains (Persaud et al. 2007); Park County, Heart and Kersey Lakes, Beartooth Absaroka Wilderness (Kessler et al. 2008).

Diacyclops crassicaudis brachycercus Kiefer, 1929

Examined material: Albany County, Libby Flats, pools of water, 12 June 2008, coll. W.K. Reeves (1♀ 1♂).

Diacyclops thomasi (S.A. Forbes, 1882)

Additional records: Albany County, Little Brooklyn and Tower Lakes, Snowy Mountain Range, Medicine Bow National Forest (Royer 1960, as *Cyclops biscuspidatus*); Albany County, Libby Lake, Medicine Bow National Forest (Sinn 1962, as *C. bicuspidatus*), Albany County, Big Brooklyn Lake, Snowy Mountain Range, Medicine Bow National Forest (Payne 1983, as *Cyclops bicuspidatus thomasi*); Park County, Beartooth Lake, Beartooth Mountains (Persaud et al. 2007), Beartooth and Island Lakes, Beartooth Absaroka Wilderness (Kessler et al. 2008); Park County, Yellowstone Lake, Yellowstone National Park (Forbes 1893; Tronstad 2008, as *Diacyclops bicuspidatus thomasi*); Sweetwater County, Flaming Gorge Reservoir (Schneidervin 1985 and Schneidervin and Hubert 1988, as *C. bicuspidatus thomasi*).

Eucyclops agilis montanus (Brady, 1878)

Examined material: Big Horn County, Greybull River, 21 October 2008, coll. W.K. Reeves (2♀); Campbell County, Coal bed methane lake No. 35, 26 August 2008, coll. W.E. Yarnell (1♀); Carbon County, Middle Cave Creek on Shirley Mountain, not in cave, 7 September 2008, colls. W.K. Reeves and R.M. Spence (1♀ 2♂ 2 immature); Carbon County, small pond near Medicine Bow, 21 September 2008, coll. W.K. Reeves (1♀ 1♂); Laramie County, North Crow Reservoir, 5 July 2008, coll. W.K. Reeves (14♀ 5♂ 15 immature); Natrona County, North Platte River, Fremont Canyon, plankton net, 25 November 2008, colls. W.K. Reeves and R.M. Spence (10♀ 9♂ 4 immature).

Eucyclops conrowae Reid, 1992

Examined material: Albany County, artesian spring into Leazenby Lake, 8 June 2008, coll. W.K. Reeves (5♀).

Eucyclops elegans (Herrick, 1884)

Examined material: Albany County, Laramie, roadside ditch, 14 July 2008, coll. W.K. Reeves (1♀); Big Horn County, Greybull River, 21 October 2008, coll. W.K. Reeves (5 immature); Natrona County, North Platte River, Fremont Canyon, plankton net, 25 November 2008, colls. W.K. Reeves and R.M. Spence (8♀ 10♂ 3 immature); Sheridan County, Holly Pond, 1 October 2008, coll. R.M. Spence (2♀ 3 immature).

Macrocyclops albidus (Jurine, 1820)

Examined material: Albany County, Optimist Park, pond, 19 June 2008, coll. W.K. Reeves (1♀); Albany County, "Stink Pond" sulfur pond and spring, 11 November 2008, coll. W.K. Reeves (1♂); Laramie County, North Crow Reservoir, 5 July 2008, coll. W.K. Reeves (6♀ 1 immature); Sheridan County, Holly Pond, 1 October 2008, coll. R.M. Spence (1♀)

Microcyclops rubellus (Lilljeborg, 1901)

Examined material: Albany County, roadside ditch in Laramie, 14 July 2008, coll. W.K. Reeves (3♀ 11 immature); Campbell County, Coal bed methane lake No. 39, 26 August 2008, coll. W.E. Yarnell (3 immature); Campbell County, Coal bed methane lake No. 40, 26 August 2008, coll. W.E. Yarnell (1♀); Platte County, Big Laramie River below Bluegrass River diversion, 10 August 2008, coll. W.K. Reeves (1 ♀).

Orthocyclops modestus (Herrick, 1883)

Additional records: Park County, Grebe Lake, Yellowstone

National Park (Forbes 1893, as *Cyclops capilliferus* n. sp.); Park County, Kersey Lake, Beartooth Absaroka Wilderness (Kessler et al. 2008).

Paracyclops chiltoni G. M. Thomson, 1883

Examined material: Platte County, pond and spring, Tunnel Road, 10 August 2008, coll. W.K. Reeves; Platte County, Big Laramie River below Bluegrass River diversion, 10 August 2008, coll. W.K. Reeves (1♂ 1 immature).

Tropocyclops prasinus (Fischer, 1860)

Examined material: Sheridan County, Holly Pond, 1 October 2008, coll. R.M. Spence (1♂).

Family Lernaeidae

Lernaea cyprinacea Linnaeus, 1761

Additional records: Platte County, Grayrocks Reservoir, Ex rainbow trout and brown trout; Wyoming, Ex *Catostomus commersoni*, *Catostomus latipinnis*, *Cyprinus carpio*, *Gila atraria*, *Gila robusta*, *Platygobio gracilis*, *Richardsonius balteatus*, *Semotilus atromaculatus*, *Esox lucius* x *E. masquinongy*, *Oncorhynchus clarki*, *Onchorhynchus mykiss*, and *Salmo trutta* from Wyoming (Mitchum 1995).

Order Harpacticoida
Family Canthocamptidae

Attheyella nordenskioldii (Lilljeborg, 1902

Examined material: Crook County, spring along road near Hulett, Black Hills, 19 June 2008, coll. W.K. Reeves (3♀ 3♂).

Bryocamptus alleganiensis Coker, 1934

Examined material: Carbon County, Cave Creek Cave, 23 September 2008, coll. W.K. Reeves (2♀ 3♂).

Bryocamptus hiemalis (Pearse, 1905)

Examined material: Carbon County, Cave Creek Cave, 23 September 2008, coll. W.K. Reeves (2♀).

Maraenobiotus brucei (Richard, 1898)

Examined material: Carbon County, Harney Creek trail bog, 16 July 2008, coll. W.K. Reeves (3♀ 2♂ 1 immature).

Maraenobiotus husmanni Flössner, 1989

Examined material: Albany County, spring in Libby Flats, 23 July 2008, coll. W.K. Reeves (3♀ 1♂).

Maraenobiotus insignipes (Lilljeborg, 1902)

Examined material: Albany County, Big Telephone Lake, 11 September 2008, coll. W.K. Reeves (3♀); Carbon County, South Fork French Creek, in moss along creek, 3109 m elevation, 28 June 2008, coll. W.K. Reeves (20♀ 10♂).

Moraria mrazeki T. Scott, 1903

Examined material: Crook County, spring along road near Hulett, Black Hills, 19 June 2008, coll. W.K. Reeves (1♂).

Order Harpacticoida
Family Laophontidae

Onychocamptus mohammed (Blanchard & Richard, 1891)

Examined material: Albany County, roadside ditch in Laramie, 14 July 2008, coll. W.K. Reeves (6♀ 2♂).

Order Poecilostomatoida
Family Ergasilidae

Ergasilus arthrosis Roberts, 1969

Additional records: Ex channel catfish *Ictalurus punctatus* (Rafinesque, 1818) in Wyoming (Mitchum 1995).

Ergasilus caeruleus C. B. Wilson, 1911

Additional records: Teton County, from Emma Matilda Lake, Two Ocean Lake, and Snake River (Bangham 1951), Ex Utah silverside minnow *Richardsonius balteatus hydrophlox* (Cope, 1872), Teton County, Polecat Creek (Bangham 1951); Wyoming, Ex Bonneville spring dace *Rhinichthys osculus carringtonii* (Cope, 1872), Wyoming, from 15 lakes and streams (Bangham 1951), Ex Utah chub *Gila atraria* (Girard, 1856; given as G. straria), Ex black crappie *Pomoxis nigromaculatus* (Lesueur, 1829) in Wyoming (Mitchum 1995).

Ergasilus centrarchidarum Wright, 1882

Additional records: Ex white sucker *Catostomus commersoni* (Lacépède, 1803), Wyoming (Mitchum 1995).

Ergasilus cyprinaceus Rogers, 1969

Additional records: Ex fathead minnow *Pimephales promelas* Rafinesque, 1820, Wyoming (Mitchum 1995).

Ergasilus nerkae Roberts, 1963

Additional records: Teton County, Ex Utah sucker *Catostomus ardens* Jordan and Gilbert, 1881 from the Snake River and Emma Matilda Lake (Bangham 1951, as *Ergasilus* sp., and host as rosyside sucker *C. fecundus*; see comments by Roberts 1970; Mitchum 1995); Teton County, Jackson Lake, (Mitchum 1995; Teton County, Ex Utah chub *Gila* [please, complete genus name] *atraria* from Emma Matilda Lake (Roberts 1970, from material identified by Bangham 1951 as *Ergasilus caeruleus*; Mitchum 1995).

Order Siphonostomatoida
Family Lernaeopodidae

Salmincola californiensis (Dana, 1852)

Additional records: Park County, Ex cutthroat trout *Oncorhynchus clarkii clarkii* (Richardson, 1836) from Yellowstone Lake (Simon 1934, as *Salmincola carpenteri* – host reported as *Salmo lewisi*; Bangham 1951, as *Salmincola* sp. – host reported as *Salmo clarkii lewisi* (Girard, 1856); Heckmann 1971 and Heckmann and Ching 1987, as *Salmincola* sp. – host reported as *Salmo clarki*); Park County, Ex *O. clarki* and rainbow trout *Oncorhynchus mykiss* (Walbaum, 1792) from Yellowstone Park (Kabata 1969, cited by Mitchum 1995), Ex *O. clarki*, *O. mykiss*, and *S. namaycush* in Wyoming (Mitchum 1995); Teton County, Ex lake trout *Salvelinus namaycush* (Walbaum, 1792), from Jackson Lake (Bangham 1951, as *Salmincola* sp. – host reported as Mackinaw trout *Cristivomer namaycush namaycush*, see discussion by Mitchum 1995).

Salmincola thymalli (Kessler, 1868)

Additional records: Ex mountain whitefish *Prosopium williamsoni* (Girard, 1856), Wyoming (Mitchum 1995).

DISCUSSION

Copepods are often underreported in biological diversity studies and the meager list of 41 species for the state of Wyoming is almost certainly an underrepresentation of the state's' true taxonomic diversity. I did not collect any undescribed species however these could be found with more extensive surveys, especially if the survey focused on isolated or unique habitats such as warm springs, caves, isolated saline ponds, and similar habitats. This checklist is the first comprehensive list of copepods for Wyoming and can be used for future studies and baseline biodiversity data.

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